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Spatial variation of seismic radiation properties for large interplate earthquakes in northeast Japan

KUBO, Hisahiko[1*] ; IWATA, Tomotaka[2] ; ASANO, Kimiyuki[2] ; AOI, Shin[1]

[1]National Research Institute for Earth Science and Disaster Prevention, [2]Disaster Prevention Research Institute, Kyoto University

Kubo et al. (2014, AGU) constructed kinematic source models for the 2011 Tohoku-oki earthquake (M_w 9.1) in multi successive period-bands using strong-motion data, and discussed the period-dependent seismic radiation and broadband source characteristics for this event based on the spatial difference of the slip velocity function for each period-band. This multi period-band source modeling has an advantage that this method provides the direct comparison among source models in multi period-bands. In this study, we investigate the period-dependent seismic radiation for the 2011 Ibaraki-oki earthquake (M_w 7.9), which is the largest aftershock of the 2011 Tohoku-oki earthquake, using the same procedure as Kubo et al. (2014, AGU) in order to compare the rupture behaviors of these earthquakes and take the first step for the discussion on the spatial variation of seismic radiation properties for large interplate earthquakes in northeast Japan.

The analysis period-bands for the 2011 Ibaraki-oki earthquake is 5-10 s, 10-25 s, and 25-50 s. The source model for each period-band is estimated by the fully Bayesian kinematic source inversion with the multi-time-window method (Kubo et al., 2014, SSJ). Three components of strong-motion velocity waveforms at 15 stations of K-NET, KiK-net, and F-net of NIED are used in this analysis. Green's functions are calculated by the FDM (GMS; Aoi & Fujiwara, 1999) with a 3D velocity structure model (JIVSM; Koketsu et al., 2012). The validity of the 3D velocity structure model used for the 3D Green's functions was confirmed through waveform comparisons for M~6 events. A curved fault model is constructed based on the shape of the plate boundary of JIVSM, and then is divided into 144 subfaults of approximately 10 km $\times$ 10 km. The slip time history of each subfault is represented by a series of nine smoothed-ramp functions with 4.0 s width, each of which is put with 2.0 s lag. The first time-window triggering velocity of 2.0 km/s is selected so as to minimize the residual of strong-motion data fitting in the period-band of 5-50 s.

The estimated rupture process in the period-band of the 5-10 s differs from those estimated in the period-bands of 10-25 s and 25-50 s. The source models in period-bands of 10-25 s and 25-50 s have large slips in the shallow area south and southeast of the hypocenter, while large slips for the source model in the period-band of 5-10 s are located in the deep area which is approximately 30 km west of the hypocenter. This means that these regions mainly radiated the long-period (10-25 s and 25-50 s) and relatively-short-period (5-10 s) waves, respectively. These results indicate that the 2011 Ibaraki-oki earthquake had an along-dip variation in its seismic radiation, which is consistent with the along-dip segmentation of interplate fault suggested by Lay et al. (2012).

The comparison of the results for the 2011 Tohoku and the 2011 Ibaraki earthquakes indicates that the seismic radiation for both events was segmented along the dip direction: short- and long-period seismic waves were predominantly radiated from the deep and shallow regions, respectively. However, the deep off-Miyagi region during the 2011 Tohoku earthquake radiated not only short- but also long-period waves, and this implies the possibility of the spatial variation of seismic radiation property in northeast Japan. This is also supported by previous studies which have noted different seismic radiation properties among other large interplate earthquakes in the northeast Japan, although the details of the seismic radiation for the other earthquakes are not clear and it is necessary to apply the multi period-band source modeling to these events.

[Acknowledgments] The strong-motion data recorded by K-NET, KiK-net, and F-net of NIED was used for this analysis.

Keywords: Spatial variation of seismic radiation property, Large interplate earthquakes in northeast Japan, Multi period-band source modeling, Strong-motion data, The 2011 Tohoku-oki earthquake, The 2011 Ibaraki-oki earthquake